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(54) Solenoid-actuate valve assembly.

(57) A solenoid-actuated valve assembly (10) has first and second valve members (18,24), first and second valve seats (26,28), a solenoid coil (40), a first permanent magnet armature (32) effective, when the coil (40) is energized with a positive current, to permit displacement of the first valve member (18) from the first valve seat (28); and a second permanent magnet armature (44) effective, when the coil (40) is energized with a negative current, to displace the second valve member (24) from the second valve seat (26). The first armature (32) is further effective, when the coil (40) is energized with a negative current, to bias the first valve member (18) into engagement with the first valve seat (28), and said second armature (44) is further effective, when the coil (40) is energized with a positive current, to bias the second valve member (24) into engagement with the second valve seat (26).

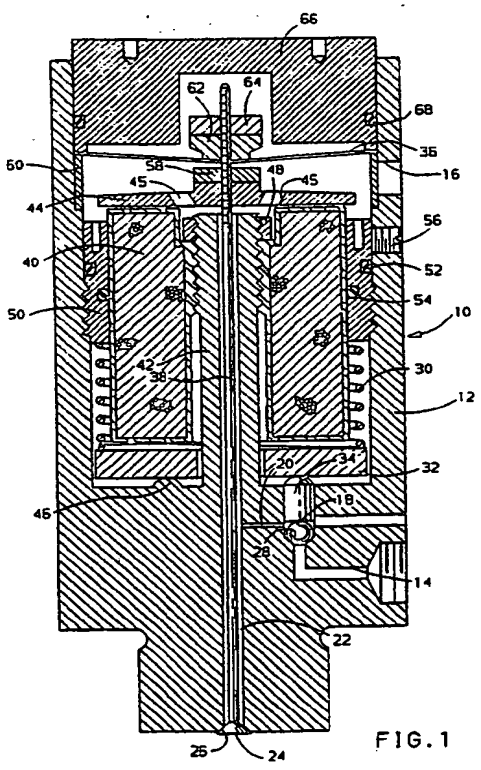

FIG.1

EP 0 404 357 A2

SOLENOID-ACTUATED VALVE ASSEMBLY

Technical field

This invention relates to a solenoid-actuated valve assembly suitable for use as an injector adapted to deliver a charge of fuel and air directly into a engine combustion chamber as specified in the preamble of claim 1, for example as disclosed in US-A-4,759,335.

A solenoid-actuated valve assembly according to the present invention is characterised by the features specified in the characterising portion of claim 1.

Summary of the drawings

Figure 1 is a schematic axial sectional view of one injector employing this invention.

Figure 2 is a view of the Figure 1 injector showing the position of parts thereof during fuel-metering.

Figure 3 is a view of the Figure 1 injector showing the position of the parts during delivery of a fuel-air charge.

Figure 4 is a schematic axial sectional view of another injector employing this invention.

Figure 5 is a view of the Figure 4 injector showing the position of parts thereof during fuel-metering.

Figure 6 is a view of the Figure 4 injector showing the position of the parts during delivery of a fuel-air charge.

Detailed description

Referring first to Figures 1-3, an injector 10 has a body 12 that receives fuel through an inlet 14 and air through an inlet 16. A ball-type fuel metering valve 18 controls inlet 14; when ball valve 18 is opened, fuel is metered through an orifice 20 to a central passage 22 and a poppet-type charge-delivery valve 24 which engages a valve seat 26 surrounding the lower end of passage 22; when opened, valve 24 delivers a charge of fuel and air directly into an engine combustion chamber.

Ball-valve 18 is biased against a seat 28 in inlet 14 by a coil spring 30 acting through a disc 32 and a push-rod 34. Poppet valve 24 is biased against seat 26 by a diaphragm-type spring 36 acting on a stem 38 of poppet valve 24.

Disc 32 is a permanent magnet armature of a coil 40 threaded onto a centre post 42 in body 12. When coil 40 is energized with a positive current as shown in Figure 2, coil 40 attracts disc armature 32 against the bias of spring 30, the fuel pressure in inlet 14 lifts ball-valve 18 and push-rod 34, and fuel flows around ball 18 and is metered through orifice 20 to central passage 22. When the desired amount of fuel has been metered into passage 22, coil 40 is de-energized, and spring 30 re-engages fuel-metering valve 18 with its seat 28.

Another permanent magnet armature 44 is secured on valve stem 38. Armature 44 has apertures 45 that allow air to flow from inlet 16 to passage 22. When coil 40 is energized with a negative current as shown in Figure 3, coil 40 attracts armature 44 against the bias of spring 36, poppet valve 24 is displaced from seat 26, and the fuel-air charge in passage 22 is delivered into the engine. When the charge has been delivered into the engine, coil 40 is de-energized, and spring 36 re-engages charge-delivery valve 24 with its seat 26.

When coil 40 is energized with a positive current to attract armature 32 and meter fuel into passage 22, armature 44 is repelled and adds to the valve-closing force of spring 36 to maintain charge-delivery valve 24 engaged with seat 26. When coil 40 is energized with a negative current to attract armature 44 and deliver the fuel-air charge from passage 22, armature 32 is repelled and adds to the valve-closing force of spring 30 to maintain fuel-metering valve 18 engaged with seat 28.

When armature 32 is in the position shown in Figures 1 and 3, it engages stops 46 which maintain it in proper alignment in body 12.

Injector 10 is assembled by placing ball-valve 18 and push-rod 34 in body 12, placing armature 32 and spring 30 in body 12, and threading coil 40 on post 42. Coil 40 is screwed on post 42 until it makes contact with armature 32, i.e., until it is bottomed out against armature 32. Coil 40 is then unthreaded, i.e., backed out the proper amount to set a desired air gap between armature 32 and coil 40. A lock-nut 48 is threaded onto post 42 to hold coil 40 in the desired position. An adjustment ring 50 is threaded into body 12 and positioned to set the desired force of spring 30; O-rings 52 and 54 seal ring 50 to body 12 and coil 40, and a set-screw 56 holds ring 50 in the desired position. Poppet valve 24 is inserted into body 12, and armature 44 is threaded onto valve stem 38. Armature 44 is screwed on valve stem 38 until it is bottomed out against coil 40, then it is backed out the proper amount to set a desired air gap between armature 44 and coil 40. A lock-nut 58 is threaded onto stem 38 to hold armature 44 in the desired position. A clamp ring 60 is inserted into body 12, and spring 36 is fitted into body 12 and over stem 38. An adjustment nut 62 is threaded onto stem 38

and is positioned to set the desired force of spring 36; a lock-nut 64 is threaded onto stem 38 to hold adjustment nut 62 in the desired position. A cap 66 is threaded into body 12 to secure spring 36 and close the top of body 12; an O-ring 68 seals cap 66 to body 12.

Referring next to Figures 4-6, an injector 110 has a multi-piece housing 112 that receives fuel through a fuel-supply tube 114 and air through an air-supply tube 116. A ball-type fuel-metering valve 118 controls fuel flow from tube 114; when ball-valve 118 is opened, fuel is metered through an orifice 120 to a cavity 122. A poppet-type charge-delivery valve 124 engages a valve seat 126 in a nozzle 127 opening from the lower end of cavity 122; when opened, valve 124 delivers a charge of fuel and air directly into the engine.

Ball-valve 118 is biased against a seat 128 by a coil spring 130 acting through a disc 132, a push-rod 133 threaded into disc 132, and a pin 134. Poppet valve 124 is biased against seat 126 by a coil spring 136 acting through a disc 137 threaded onto the stem 138 of poppet valve 124.

Discs 132 and 137 are permanent magnet armatures of a coil 140 wound on a magnetic core 142. When coil 140 is de-energized as shown in Figure 4, armature 132 is attracted toward the top of core 142, engaging ball valve 118 with its seat 128, whilst armature 137 is attracted toward the bottom of core 142, engaging poppet valve 124 with its seat 126.

When coil 140 is energized with a positive current as shown in Figure 5, coil 140 repels armature 132 against the combined bias of spring 130 and the magnetic attraction between armature 132 and core 142, the fuel pressure in inlet 114 lifts ball-valve 118 and pin 134, and fuel flows around ball 118 and is metered through orifice 120 to cavity 122. When the desired amount of fuel has been metered into cavity 122, coil 140 is de-energized, and the combined bias of spring 130 and the magnetic attraction between armature 132 and core 142 re-engages fuel-metering valve 118 with its seat 128.

When coil 140 is energized with a negative current as shown in Figure 6, coil 140 repels armature 137 against the combined bias of spring 136 and the magnetic attraction between armature 137 and core 142, poppet valve 124 is displaced from seat 126, and the fuel-air charge in cavity 122 is delivered into the engine. When the charge has been delivered into the engine, coil 140 is de-energized, and the bias of spring 136 and the magnetic attraction between armature 137 and core 142 re-engages charge-delivery valve 124 with its seat 126.

When coil 140 is energized with a positive current to repel armature 132 and meter fuel into cavity 122, armature 137 remains attracted to core 142 and adds to the valve-closing force of spring 136 to maintain charge-delivery valve 124 engaged with seat 126. When coil 140 is energized with a negative current to repel armature 137 and deliver the fuel-air charge from cavity 122, armature 132 remains attracted to core 142 and adds to the valve-closing force of spring 130 to maintain fuel-metering valve 118 engaged with seat 128.

Injector 110 is assembled by inserting nozzle 127 in housing 112, an adjusting plate 145 being threaded on the upper end of nozzle 127 and fitting over an anti-rotation pin 147 carried by housing 112. A lock-nut 149 is threaded onto nozzle 127 to hold it in place. A stop 151 is inserted against a shoulder 153 in housing 112, spring 136 is installed, and poppet valve 124 is inserted. Armature 137 is threaded onto valve stem 138 until the top of armature 137 is aligned with a shoulder 155 in housing, and coil 140 is inserted against shoulder 155 and secured with a set-screw 157. The clearance between coil 140 and armature 137 is adjusted as desired by rotating valve 124 whilst holding armature 137 against rotation, and a lock-nut 159 is threaded onto valve stem 138. Nozzle 127 is rotated within housing 112 and plate 145 to adjust the force exerted by spring 136, and lock-nut 149 is then tightened. A plenum member 161, including ball-valve 118, pin 134 and fuel-supply tube 114, is inserted against a shoulder 163 in core 142. Armature 132 is inserted against the top of coil 140, push-rod 133 is adjusted to engage ball-valve 118 against its seat 128, and a lock-nut 164 is threaded on the top of push-rod 133 to maintain the desired adjustment of push-rod 133. Spring 130 is inserted, and a lid 165 is threaded onto housing 112. An upper stop 167 depends from the inside of lid 165, and lid 165 is threaded onto housing 112 until stop 167 first engages armature 132, and then lid 165 is unscrewed sufficiently to establish a desired distance between armature 132 and stop 167. A lock-screw secures lid 165 to housing 112. Lid 165 also carries a screw 169 that is adjusted to establish the desired force exerted by spring 130, and a lock-nut 171 is threaded about screw 169. A split lock-nut 173 is tightened about fuel-supply tube 114 to assure that plenum member 161 remains against shoulder 163.

Claims

1. A solenoid-actuated valve assembly (10;110) comprising first and second valve members (18,24;118,124), first and second valve seats (26,28;126,128), a solenoid coil (40;140), a first permanent magnet armature (32;132) operatively connected to the first valve member (18;118) and

effective, when the coil (40;140) is energized, to permit displacement of the first valve member (18;118) from the first valve seat (28;128), and a second permanent magnet armature (44;137) operatively connected to the second valve member (24;124) and effective, when the coil (40;140) is energized, to displace the second valve member (24;124) from the second valve seat (26;126), characterised in that said first permanent magnet armature (32;132) is effective, when the coil (40;140) is energized with a positive current, to permit displacement of the first valve member (18;118) from the first valve seat (28;128); said second permanent magnet armature (44;137) is effective, when the coil (40;140) is energized with a negative current, to displace the second valve member (24;124) from the second valve seat (26;126); said first armature (32;132) is further effective, when the coil (40;140) is energized with a negative current, to bias the first valve member (18;118) into engagement with the first valve seat (28;128), and said second armature (44;137) is further effective, when the coil (40;140) is energized with a positive current, to bias the second valve member (24;124) into engagement with the second valve seat (26;126).

2. An injector containing a solenoid-actuated valve assembly (10;110) according to claim 1, for injecting a charge of fuel and air directly into an engine combustion chamber,
characterised in that the injector (10;110) has an air inlet (16;116) and a fuel inlet (14;114), the first valve seat (28;128) is associated with the fuel inlet (14;114); the first valve member (18;118) is a fuel-metering valve member; there is a spring (30;130) biasing the fuel-metering valve (18;118) to engage the fuel inlet valve seat (28;128), the second valve seat (26;126) is a valve seat through which a charge of fuel and air is delivered to the engine, the second valve member (24;124) is a charge-delivery valve member, and there is a spring (36;136) biasing the charge-delivery valve (24;124) to engage the charge-delivery valve seat (26;126).

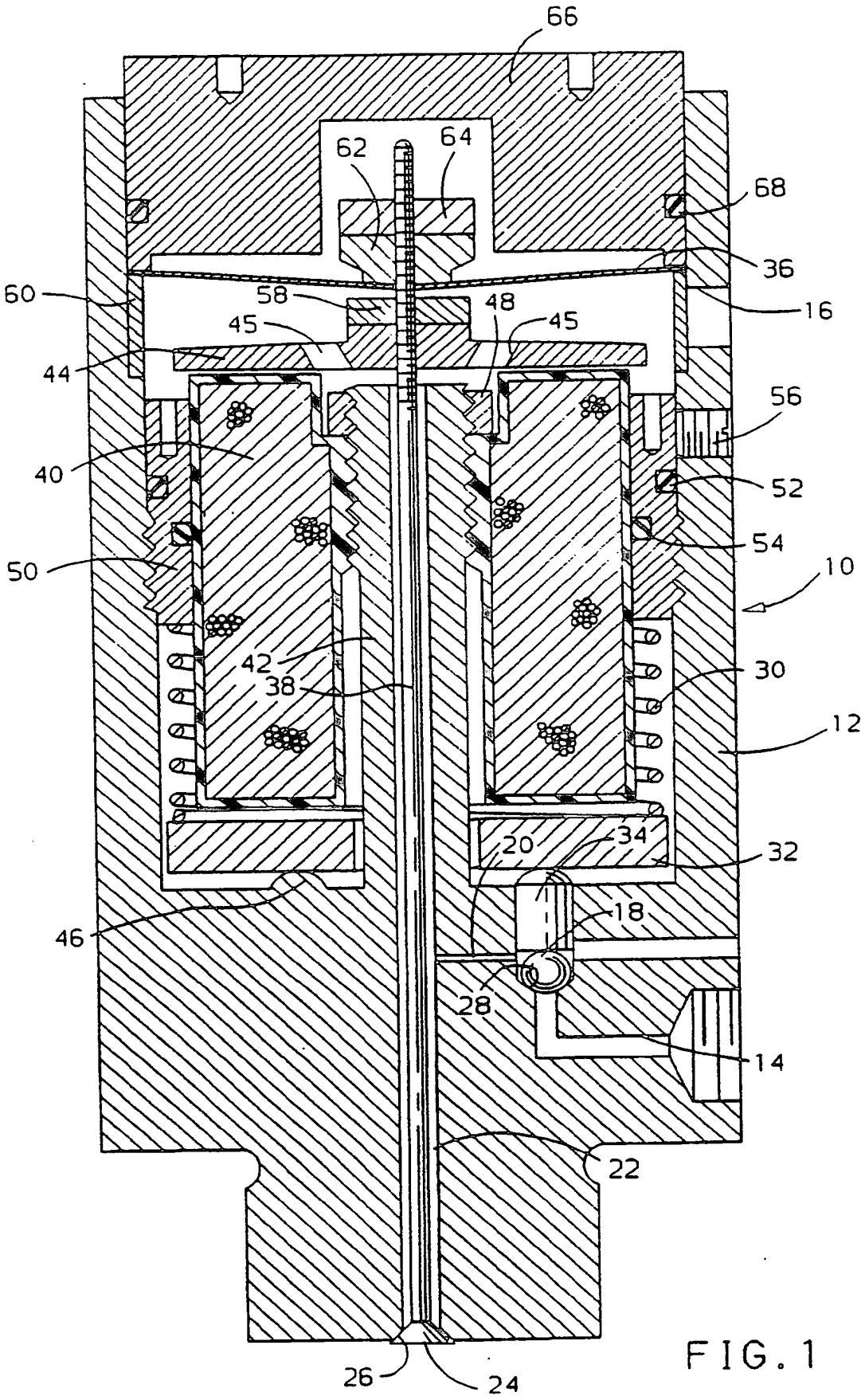
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FIG. 1

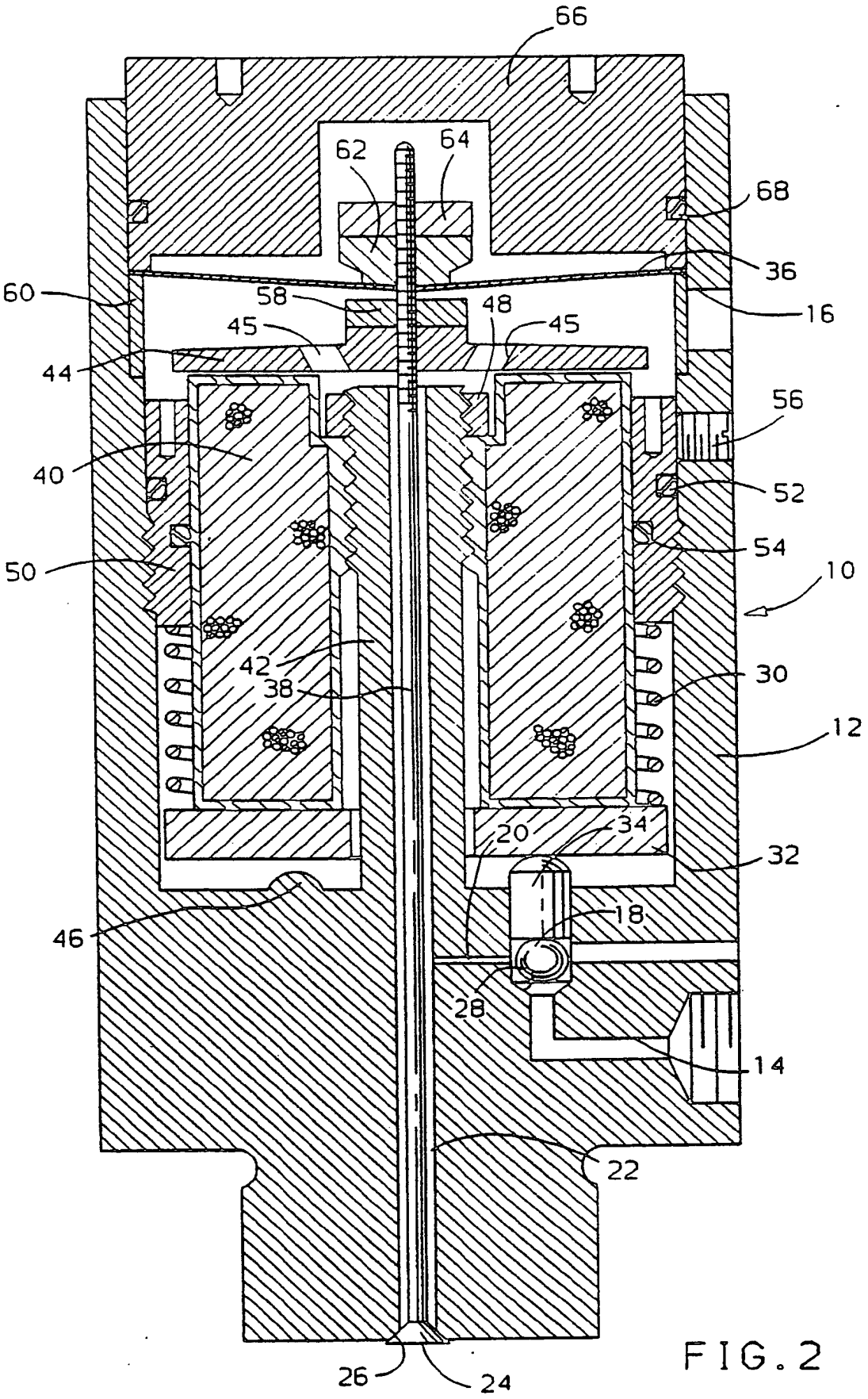

FIG. 2

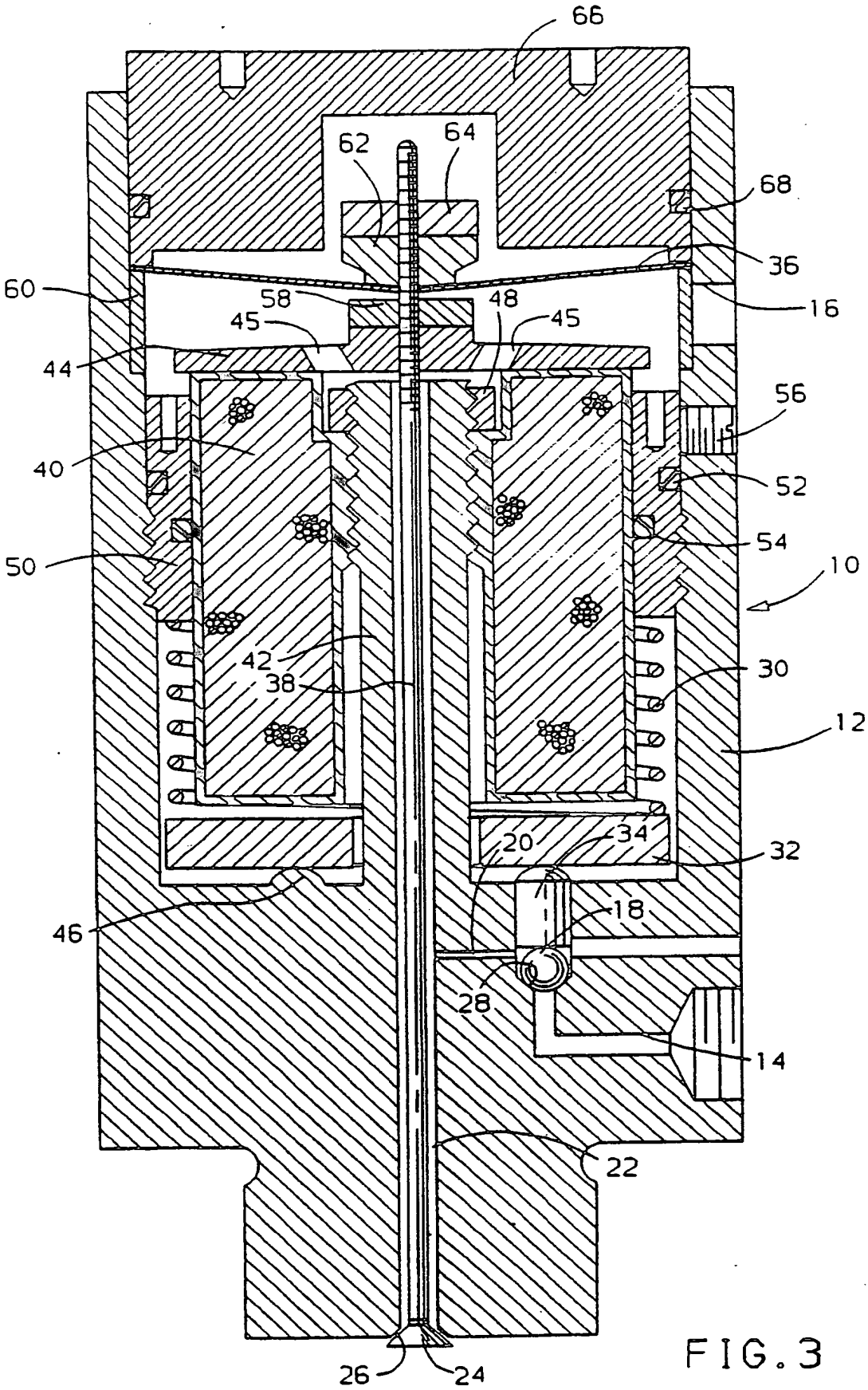
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FIG. 3

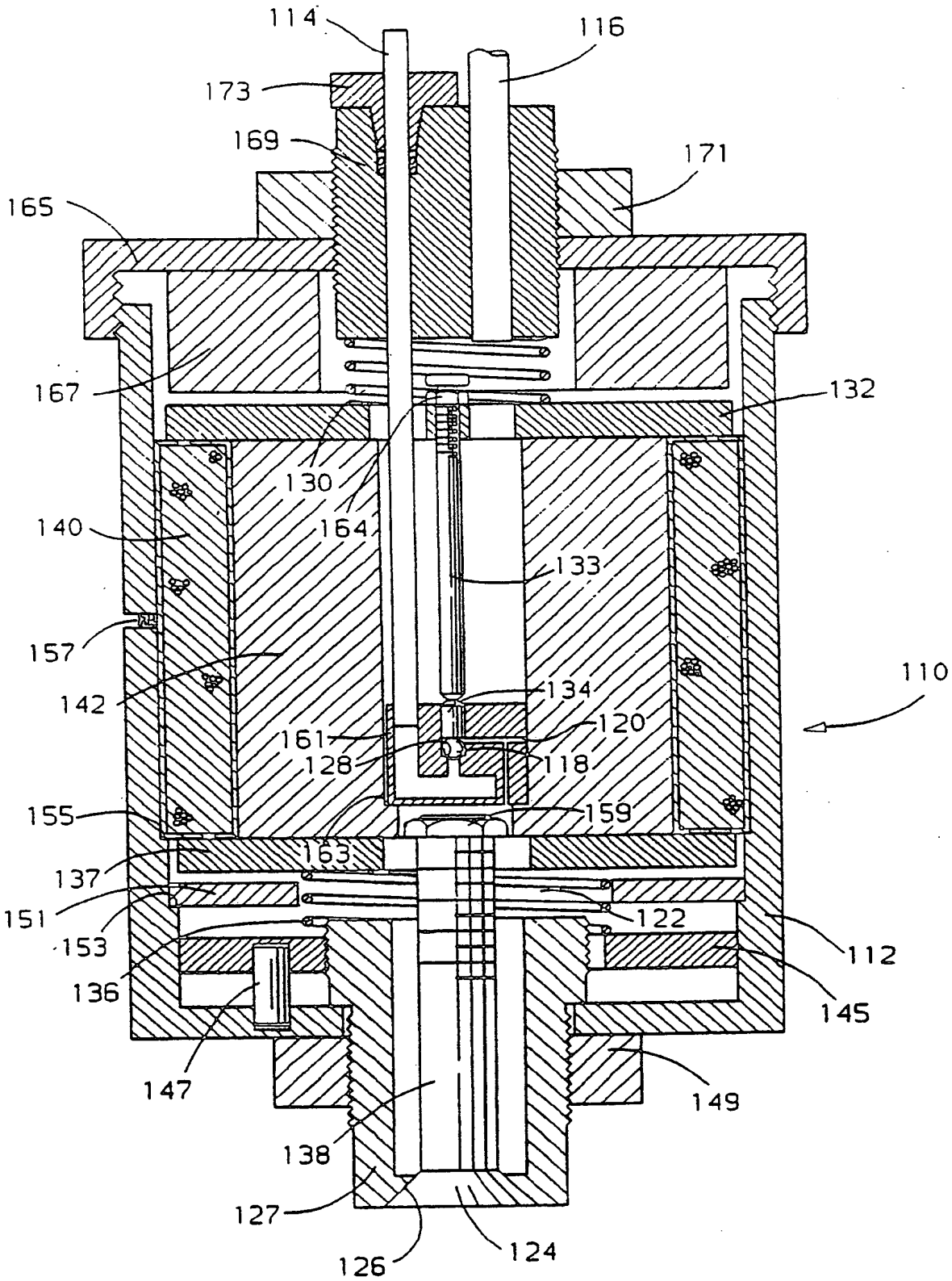

FIG. 4

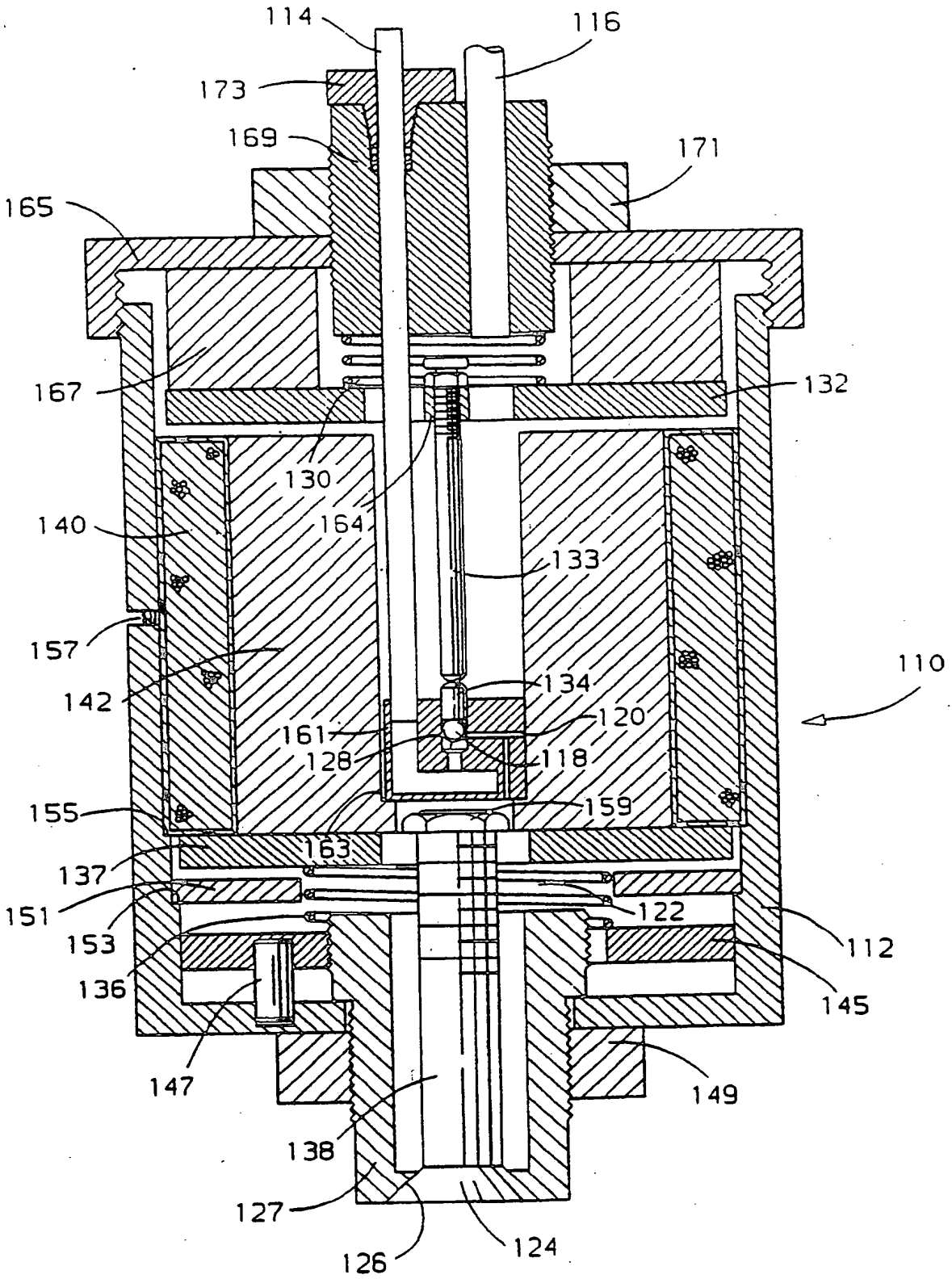
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FIG.5

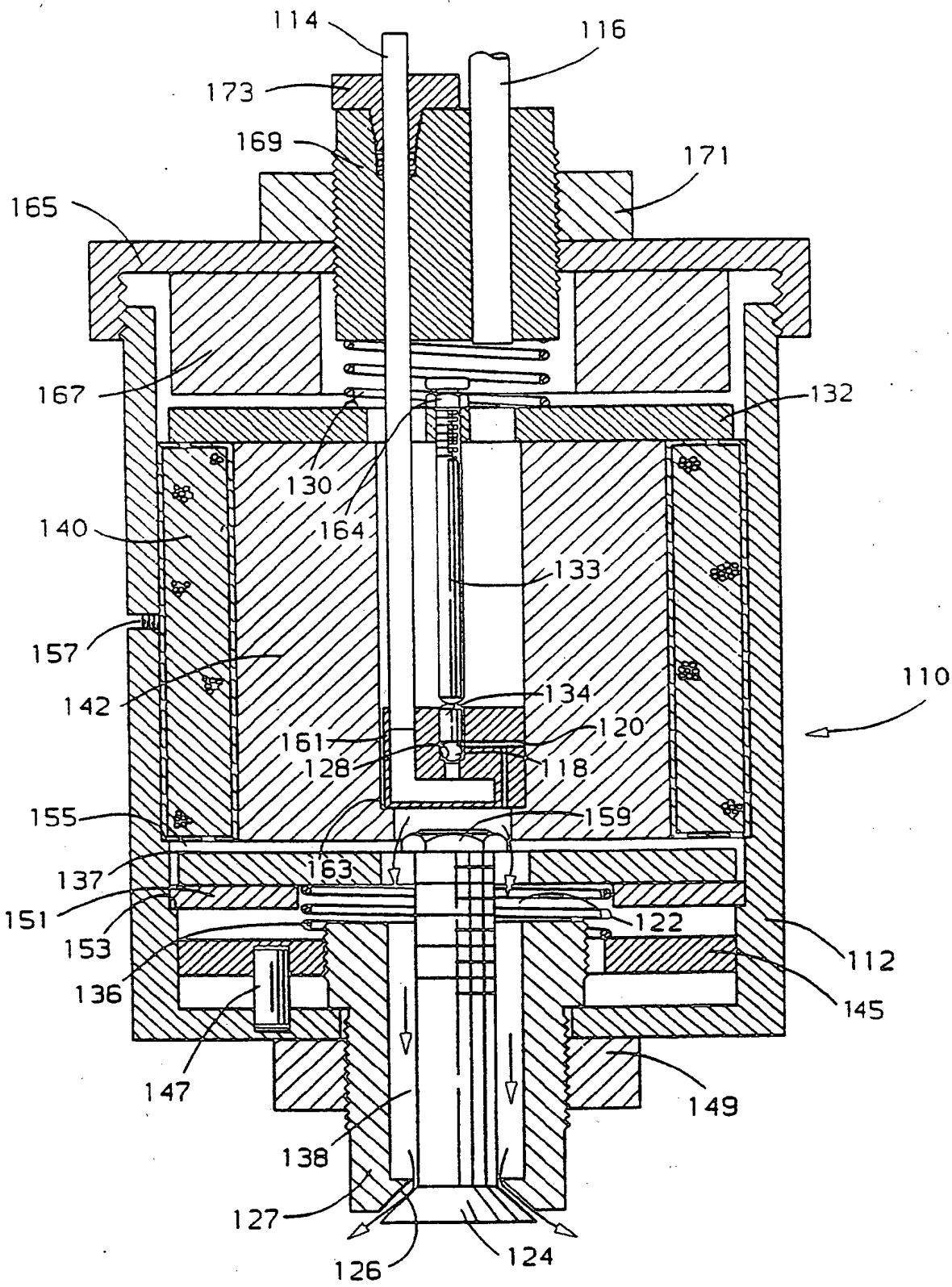
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FIG. 6

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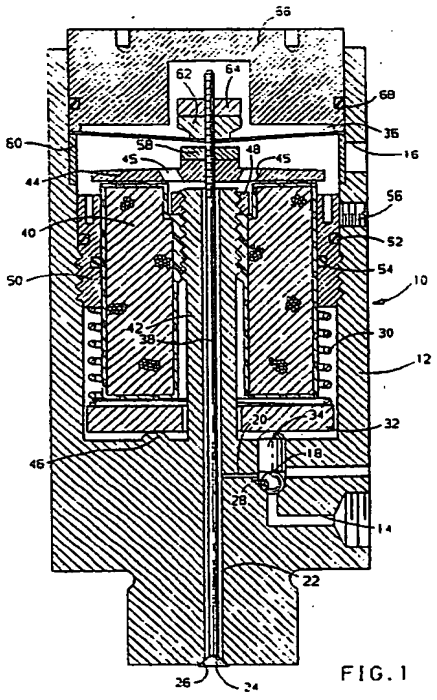

FIG. 1

EP 0 404 357 A3

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EUROPEAN SEARCH REPORT

Application Number

EP 90 30 5660

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X,Y	US-A-4 506 701 (MASAKI ET AL.) * column 2, line 54 - column 4, line 48; figure 1 *	1,2	F 02 M 51/08 F 02 M 61/08 F 02 M 67/12
Y	US-A-4 020 803 (THUREN ET AL.) * column 3, line 11 - column 4, line 28; figure 2 *	2	
A	WO-A-8 500 854 (ORBITAL ENGINE COMPANY PROPRIETARY LIMITED) * page 6, line 21 - page 7, line 20 * * page 9, lines 29 - 37 @ page 12, line 33 - page 13, line 3; figures 1, 3, 4 *	1,2	
A	US-A-4 387 696 (YOGO ET AL.) * column 2, line 31 - column 3, line 42; figure 2 *	1,2	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F 02 M
F 16 K

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	17 December 90	ALCONCHEL Y UNGRIA J

CATEGORY OF CITED DOCUMENTS

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